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ABSTRACT

This paper is based on the proposition that technology education provides a fundamental and workable framework (or curriculum construct) that can facilitate the development of improved capability in mathematics and science on the part of the student. The potential for such a workable framework in the process of having technology education play such a role is made self-evident by the strong linkages and relationships that exist between technology, mathematics, and science. In the contextual framework of using science and mathematics to understand technology, there is a very important educational principle in operation. The "how" of the interface between technology education and the disciplines of mathematics and science is in reality the bottom line in the educational process. It consists of the strategies and instruction processes that bring the principles of mathematics and science into the study of technological accomplishments for greater understanding on the part of the student. Some insights, in very practical terms, on how the "how" might be approached are provided. (KR)

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TECHNOLOGY EDUCATION -- A FUNDAMENTAL FRAMEWORK FOR IMPROVED CAPABILITY IN MATHEMATICS AND SCIENCE

THE HOW OF THE INTERFACE

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There are many frameworks upon which technology education may provide for an improved capability in mathematics and science.

D.M.

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The stated theme of this presentation as listed in the title provides us with a basic proposition from which this discussion will take place. That proposition is that -- technology education provides a fundamental and workable framework (or curriculum construct) that can facilitate the development of improved capability im mathematics and science on the part of the student.

The potential for such a workable framework in the process of having technology education play such a role is made self-evident by the strong linkages and relationships that exist between technology, mathematics and science. As a matter of fact, many people, including numerous educators, actually consider the study of science and mathematics as technology education. Such a point of view, however, lacks a perspective that puts both science or mathematics and technology in their respective places, as well as in many instances failing to establish their proper relationships.

By way of example: the science of astronomy is dependent upon the technology of the telescope. Thus, the telescope becomes a tool, an instrument or a machine for the study of the science of astronomy in the hands of the scientist astronomer. The difference here is clear. The technology is the means by which the study of the stars, galaxies, comets, planets and their movements is facilitated and enhanced, thus contributing to the knowledge base associated with the science of astronomy.

On the other hand, if one wants to study the telescope, a technological instrument, and really understand the how and why of its capability to assist in our study of the science of the stars, one must then comprehend the principles of optics and the arrangements of lenses that permit it to be useful to probe into the world beyond. The science of optics thus becomes the means by which one can begin to understand the telescope as a technological instrument.

The framework for the study of technology as a base for the development of improved capability in mathematics and science becomes a matter of "means and ends".

The scientist uses tools, instruments, and machines (technology) to probe the secrets of the Universe. Technology, in this relationship, becomes an important part of the "means" towards achieving the "ends" of greater understanding of the world beyond.

The technology educator, on the other hand, uses the knowledge of science as a "means" to achieve an understanding of technology, which may be an "end" toward which the instruction is directed.

In this contextual framework of using science and mathematics to understand technology, there is a very important educational principle in operation. Science and mathematics are being used or understood with respect to real things or technology in the form of tools, instruments, machines, processes, and materials. It is the principle of application of knowledge in relation to real and tangible items where science and mathematics become realistic and achieve a dimension of concreteness.

The "how" of the interface between Technology Education and the disciplines of mathematics and science is in reality the bottom line in the educational process. It consists of the strategies and instructional processes that bring the principles of mathematics and science into the study of technological accomplishments for greater understanding on the part of the student.

Thus the goal of increased understanding of technology becomes the primary objective towards which the interface with mathematics and science is directed. A secondary objective is the improved understanding of mathematics and science as these disciplines move from a theoretical context to a context of application and use in the interpretation and analysis of a particular technological event

or innovation. Both of these are important roles Technology Education can fulfill.

The "how" of this topic is the principal issue that moves the process from the profound and useful discussions of the futurists, the technologists, and the historians of technology into the domain of the professional technology educator.

We in this professional group of the American Industrial Arts Association (International Technology Educational Association) have exhibited great talent and capability in establishing the theoretical perspective and the logic behind the study of technology. The national organization has promulgated insightful statements that have helped to clarify the goals, as well as directions, for the concept of technology education.

This scholarship, logic, theory, and perspective on Technology Education as a discipline has been most helpful. It has tended to develop in us an awareness of the importance of looking at a new direction for education that would provide for the profession the elements of relevance, validity, and responsibility as an important part of the school program of the future.

But, in the professional educators role, it takes more than erudite and scholarly theories, postulations and rationale. If Technology Education is to have any validity in the context of a laboratory, experientially based program, it must be equally effective in achieving the "how" with which such education can take place. Our piece of that "how" issue in this discussion relates specifically to the areas of mathematics and science understanding in regard to effective technology education.

The "how" of the educational framework is manifested and brought into validity when the individual teachers in our schools close their laboratory doors and the real happenings in education take form and shape. It is here

where the tests of valdity, as well as reliability, take place with respect to what we preach and so eloquently claim for Technology Education. It is, in the language of the street, that point where the rubber hits the road -- "how" do we accomplish what we say we can and should do.

The remainder of this discussion will provide some insights, in very practical terms, how the "how" might be approached. Each of the approaches has been used with considerable success.

The "how of the interface" between technology education on the one hand, and the greater understanding of mathematics and science on the other, may be achieved through five different approaches.

I will categorize them as —

- an innovation study approach,
- a systems study approach,
- a process study approach,
- a construction study approach, and
- a research and experimentation approach.

However, it is important to note that these five approaches are not mutually exclusive of each other. That is, there is a great deal of possible cross-over among the categories, depending upon whether one wants to isolate a process, study the joined processes in a given system, or deal with a technological artifact that may combine processes as well as systems. The five categories merely provide a means of identifying, in perhaps over-simplified terms, the different approaches one might pursue in a program of technology education intended to integrate mathematics and science.

1. The "innovation study" approach takes an important technological item or innovation and uses it as a base for the study of a host of inter-disciplinary understandings associated with the object. This particular

approach has been demonstrated unsuccessfully in the anthropological approach to the study of technology.

The anthropological unit study of early technology -- tools and machines, power and energy, and communications and transportation, deals with many of the significant technological developments of the prior civilizations and cultures.

The waterwheel as a prime mover for grinding grain, irrigation, forging iron, lifting objects, etc., is in reality a system of levers. The center of the over-shot wheel's axle is the fulcrum point. The respective distances away from a vertical line from the fulcrum become levers with mathematical values depending on the quantity and velocity of flow of the water. There also is the concept of kinetic energy being transformed into mechanical energy.

The windmill, with its revolving sail structure, represents another set of science principles not too unlike the sails on a modern sailboat. Both of these involve Newton's third law -- (that for every action there must be an equal and opposite reaction) and Bernoulli's theorem -- (a reduction of pressure must be accompanied by an increase in velocity and vice-versa).

Other examples in this area of the interface of mathematics and science with the study of early technological innovation are contained in the recently published monograph (AIAA) titled Math/Science/Technology Projects (1984). Such other examples in this publication include:

- The lateen sail
- The trebuchet
- The block and tackle
- The camera
- The incandescent lamp
- The hydraulic elevator
- The Wright Brothers' airplane

Please be reminded that these are only a few examples. Practically every significant technological development has similar potential for scientific and mathematical interfacing.

Although the above are related to the anthropological unit approach, a similar kind of interfacing can be done with the same educational strategies directed toward contempoary units as well as futuristic units of study.

2. The systems study approach takes a functioning component in a larger unit and attempts to provide for an improved understanding of the particular working system through the disciplines of mathematics and science.

An excellent example in this area is the water or liquid cooling system in an automobile. This is a common system whose understanding has many linkages with principles of science and mathematics. The following are some of the more obvious: principles of heat transfer, volume in relation to heat, conduction, convection currents, metallic properties, bi-metal interactions, chemistry of coolants, evaporating pressures, expansion and contraction principles, and many more. It is one integrated system in a machine that is made up of numerous systems.

- A similar analysis of mathematical and science principles may be made with regard to the propulsion system, suspension system, brake systems, and steering systems on an automobile.
- The modern airplane or jet aircraft is likewise made up of a series of systems that can be analyzed for their mathematical and science principles and concepts.
- Nuclear or fossil fuel power generation plant is another technological development that is composed of a number of connected systems that may be isolated and better understood in terms of their mathematics and science principles.

3. The process study approach provides one of the most abundant sources of opportunities for the integration of mathematics and science principles and concepts for greater understanding of technology commonly used in the Technology Education laboratories in our schools. The process approach deals with a more micro form of technological involvement on the part of the student. It actually involves the forming, shaping, fabricating, and constructing processes commonly carried out in the design, development and making of technological items in the technology laboratory.

The following examples are used to illustrate the process category for the integration of science and mathematics principles or concepts.

- The brazing of metals (cast iron with a bronze rod, flux and oxy-acetylene torch) is a classic example. Such a process opens the way for understandings in the areas of -- properties of dissimilar metals, heat exchanges, metallurgical properties of metals, expansion rates and calculations, oxidation, gaseous isolation, gas composition, molecular structure, gas consumption, material cost, and many more.
- The process of moulding in the making of steel, aluminum, bronze, or brass castings in a school foundry unit is another example. The science and mathematics principles or concepts are related to such items as -- metallurgical properties, heat transfer, mould density, selected cooling, chilling, freezing, breathing of the sand, binder qualities, volume calculations, gas generation, shrinkage, etc.
- Another process example would include the simple act of using a brace and bit in boring a hole in a piece of wood. The science and mathematics concepts or principles are quite obvious in such areas as -- fulcrum and levers, inclined plane, the screw, action and reaction, density of material, wood structure, heat, force calculations, and many more.

- The process of taking a picture has an abundance of opportunities to further understand the process through the integration of mathematics and science into the experience. These could include such elements as - optics, optic arrangement, speed of exposure, chemistry of the film, distances, timing, film processing chemistry, light measurement, flash component functioning, and numerous others.
- Of course, practically every process involves some scientific principles or mathematical application. This would be true of such common processes as --

welding	measuring
planing	cutting
drilling	turning metals
soldering	electrical measuring
bonding	electrical circuiting
riveting	heat treating
fastening	casehardening
gluing	melting
chipping	grinding
nailing	bolting
screwing	polishing
plating	melting
spinning	indexing
etc.	etc.

4. The <u>construction</u> study approach involves the application of mathematics and science in the planning, designing, and evaluating of the object, structure, equipment or apparatus that the students are involved in making. This is a much broader dimension of interdisciplinary involvement than the previously listed technic process elements. In effect, at least in the initial stages of a project or problem, it is a case of decision-making and problem solving, using mathematical calculations and principles of science.
   - Architectural drawing, particularly the structural detailing of space, trussing, floor loading, footing design, concrete estimating, roof

design, etc., provide excellent opportunities to use mathematics and science in practical applications.

- The design of structures in the form of bridges, trestles, hangers, television antennae, roof trusses, conveyor systems, water dams, wind generator supporting units, mono-rail systems and other such items are good potentials for meaningful application of principles of science and mathematics.
- Other constructions that would provide for a rich and effective use of mathematics and science would include such projects as:

  ground effects machine

  hydro-foil craft

  airplane

  laser beam

  robot

  automatic material handling system

  electronic control units

  derby race car

  communication systems

  furniture

  land vehicles

  water vehicles

  energy developing items

  etc.

5. The <u>research and experimentation</u> or research and development approach to the study of technology, technological products and processes abounds with opportunities to integrate mathematics and science in practical and relevant applications. The R&E program has a long history of such

meaningful use of these disciplines.

Such research and experimentation might be in the areas of -- heat treatment of steels, corrosion of metals, effects of heat on finishes, strengths of fasteners, strength of adhesives, fire retardants, heat collectors, qualities of fabrics, fadeability of colors, structure strengths, structure loading, power generation, photograph developing and printing, energy conservation, strength of materials, airplane wing design, airplane configuration, boat hull design, anti-fouling paints, barge designs, automobile designs, roof designs and many more.

The R&E and R&D approaches are particularly suited to the application of principles of physics and chemistry as well as applied mathematics, which can include various levels of statistics. Data collecting and data analyses are common to most R&E efforts.

The scientific methods in conducting research, as well as problem solving, are important components of the R&E program.

The following final comments are directed towards the implications of the ideas presented in this discussion. Surely such a framework of interdisciplinary involvement and integration will require a re-evaluation of some traditional positions. It will require a posture related to the 21st century, for that is where the product (our future citizens in the schools today) will work, play and fulfill their responsibilities as citizens.

Implications for Implementing the "How"

There are those who would arise to their feet and complain that many of the teachers do not have the mathematics and science background to effectively carry out such an interfacing of mathematics and science. However, to whatever

degree of fact that condition may be, it must not become an excuse for inactivity or failure to move ahead.

- Education is a continuous process for every professional area in this society and teachers are no exception.
- Teacher education institutions will need to examine their programs and emphases in these programs.
- Teacher in-service development must look to the present and future for its direction in the upgrading of the personnel.
- The development of a form of interdisciplinary fluidity within our schools is a must if we are to accomplish a holistic form of education -- a form of education that thinks and acts on a concept of inter disciplinary partnerships rather than the predominantly present practice of protecting disciplinary turf.
- The development of new concepts of Industrial Arts/Technology Education that represent movement in theory and practice toward a society that is technologically driven and on whose understanding our future civilization will depend.

The challenge for Industrial Arts/Technology Education is obvious and likewise, the opportunities are there. However, to not become an important, integrated, respected comonent of the system can only have the most disastrous of consequences. To the profession, one can only say -- "The ball is in our court."

LITERATURE CITED

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